3.G.14 j. (cont'd) Where single-conductor cables are used for AC circuits or DC circuits with high ripple content, the following precautions should be observed in order to avoid undesirable induced currents and generated heat:

(1) Cable armor, if any, should be of non-magnetic material;
(2) There should be no closed magnetic circuit around any conductor unless it encircles all conductors of the circuit; where installed in steel conduits, pipes, or casings, the cables should be bunched so that all conductors and the neutral, if any, are enclosed by the same conduit, pipe, or casing;
(3) No magnetic material should be located between single-conductor cables of a circuit; where such cables pass through a steel deck or bulkhead, all the conductors of the circuit should pass through a non-ferrous plate or gland so that no magnetic material is located between the conductors.

Cable routing and segregation requirements are contained in 46 CFR 111.60-9 and 111.60-5, which references IEEE-45 Sections 20 and 22, except 20.11. Section 20.3 requires cables to be so routed as to avoid, so far as practicable, galleys, firerooms, and other spaces where excessive heat and high risk of fire may be encountered. SOLAS II-1/45.5.3 includes laundries in this category of spaces to be avoided.

15. Motor Circuits (46.CFR 111.70).

a. General (46 CFR 111.70-1). With the exception of steering gear motor circuits, propulsion motor circuits (which must meet 46 CFR Subparts 111.70 and 111.35, respectively) and certain special requirements applicable to fire pump motor circuits, each other motor circuit, controller, and protection must meet the requirements of ABS Rules for Building and Classing Steel Vessels (RSV Rules) or ABS Rules for Building and Classing Mobile Offshore Drilling Units (MODU Rules), as applicable. 46 CFR 111.70-1 currently references sections 4/5A5.13, 4/5B2.13, 4/5B2.15 and 4/5C4 of the 1996 RSV Rules; these correspond to sections 4-8-2/9.17, 4-8-3/5, and 4-8-4/9.5 of the 2003 RSV rules. Sections 4/3.87 through 4/3.94 and 4/3.115.6 of the 1994 MODU Rules correspond to Part 4, Chapter 3, sections 4/7.11 and 4/7.17 of the 2001 MODU Rules. Previously 46 CFR 111.70 relied on Article 430 of ANSI/NFPA 70, the National Electrical Code (NEC). In 1996 subpart 111.70 was revised to reflect internationally recognized classification society standards, practices and requirements which do not rely solely on the shoreside code of the National Electrical Code (NEC). Referencing section 430 of the NEC may still be useful as indicated in the following sections, but is no longer binding.

Diagram 430-1 in the NEC is a useful diagram of a motor circuit. The diagram serves as a guide to the applicability of the various sections of Article 430; the NEC does not require all motor circuits to be arranged as shown in the diagram. In fact, the vast majority of shipboard low-voltage motor circuits consist of the motor, a combination motor controller containing overload protection which meets NEC 430 Part C and a disconnecting means which meets 430 Part H, fuses or a circuit breaker which provide branch-circuit short-circuit and ground-fault protection per 430 Part D, and motor branch-circuit conductors meeting 430 Part B.

3.G.15 b. <u>600 Volts and Above</u>. Part K of NEC Article 430 adds to or amends the other provisions of the article for motor circuits over 600 volts. Specifically, 430-124 permits motor conductors to have an ampacity not less than the motor overload protective device trip current, which may be 100% of the rated full-load current. This applies to medium-voltage motors for applications such as thrusters and compressors. Cables for DC motors for drilling equipment (draw-works, rotary table, mud and cement pumps) may be sized in accordance with the International Association of Drilling Contractors "Interim Guidelines for Industrial System DC Cable for Mobile Offshore Drilling Units," IADC-DCCS-1. This standard is under section 3.G.15.d.

c. <u>Motor Protection</u>. Motor overload protective devices are required for most motors in order to protect the motors, motor control equipment, and motor branch-circuit conductors against excessive heating due to sustained motor overload, failure to start, or motor stalling. Continuous-duty motors of more than 1 horsepower must generally be provided with a separate overload device set to trip at not more than 115% of the motor rated full-load current. In most cases, overload relays with heater coils responsive to the motor current are included in the motor controller. The Electrical Engineering Regulations generally permit the use of only two motor overload devices for three-phase motors in lieu of the three specified in NEC Table 430-37; see 46 CFR 111.70-1(b). The size of the overload protective device should be based upon the actual nameplate full-load current rating. The values listed in columns "C" and "D" of the Quick Reference tables in section 3.G.15.e may be used to check the maximum values for running protection.

Part D of Article 430 specifies the protection of motor circuits rated 600 volts or less against overcurrent due to short circuits or grounds. A single protective device may be used to provide both branch circuit/ground-fault and motor overload protection where the overload requirements of 430-32 are met; see NEC 430-55. NEC 430-52 permits a motor short-circuit protector (MCP) to be used in lieu of the protection specified in Table 430-152 where the motor short-circuit protector is a part of a combination controller which has both motor overload protection and short-circuit and ground~fault protection in each conductor and where it will operate at not more than 1300 percent of motor full-load current.

Motor controllers, also called "starters," are used to manually or automatically start electric motors from a local or remote location. Motor controllers basically consist of a relay or "contactor," which is used to connect the motor to the AC line by a pushbutton switch, liquid level switch, pressure switch, temperature switch, etc. The two types of controllers used are "low voltage release" (LVR) and "low voltage protection" (LVP). Both can appear to be identical, but their electrical circuits will vary. LVR controllers are required for vital systems to ensure that the equipment will re-start following either a loss of power or a reduction in voltage below the "drop-out" value of the operating coil. These controllers are usually energized by contacts that mechanically remain closed when power is lost. LVP controllers are energized by momentary contacts, such as a

3.G.15 c. (cont'd) pushbutton. They will not re-start following a power outage until the momentary pushbutton contact is again depressed.

Motor controllers are furnished with the thermal overload elements mentioned above. These elements are used to open (or close) contacts which are used either in the control circuit itself or to provide an overload alarm to another circuit.

Some of these elements are adjustable but most often the non-adjustable type is specified. Most motors are stopped by these (normally closed) contacts when an overload occurs. For vital systems, such as steering, these devices are used only to signal the overload condition in a separate circuit.

Safety disconnects: Each motor circuit must have a disconnecting means capable of disconnecting both the motor and the controller from the circuit. The disconnect and the controller may be contained within the same enclosure; the disconnect must, however, open all ungrounded supply conductors to the controller and motor control circuits. Switches and circuit breakers used as disconnecting means for low-voltage motor circuit must have ampere rating of at least 115 percent of the motor full-load current. The use of fuses as disconnects, although permitted by the NEC, is specifically prohibited by 46 CFR 111.70-1(c). Electric heaters in motor controller enclosures should not be accepted from the disconnecting requirements in 46 CFR 111.70-5(a). The purpose of this requirement is to eliminate the shock hazard posed to personnel by an enclosure with more than one source of potential, and is consistent with the intent of NEC 430-113. To allow for safe access during maintenance and inspection shutdown periods, a disconnecting device for an electric heater in a motor controller enclosure, or one of the protection features required by 111.70-7(d) for control, interlock or indicator circuits should be provided.

d. Interim Guidelines For MODUs. Reference 3.G.15.b

INTERNATIONAL ASSOCIATION DRILLING CONTRACTORS

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INTERIM GUIDELINES
FOR INDUSTRIAL SYSTEM DC CABLE
FOR MOBILE OFFSHORE DRILLING UNITS
IADC-DCCS-1

I. Purpose

These interim guidelines have been prepared to establish a method for the selection, installation and acceptance of DC electrical cables used on industrial drilling systems on mobile offshore drilling units. These systems are drawworks, pumps and rotary table. These interim guidelines will provide the necessary

3.G.15 d. (cont'd) guidelines for DC cable on MODUs until a final standard has been prepared and issued.

II. Single Conductor Cable Selection

For all cable types, the following shall apply:

A. The interim guidelines shall apply to DC motors nominally rated 750 volts DC armature voltage.

B. The cable size per polarity shall have a current-carrying capacity determined by multiplying the duty factor times the lesser of:

1. The continuous current rating of the motor; or
2. The continuous current limit setting of the power supply.

C. The duty factors to be used are:

1. Mud pumps, cement pumps: 0.80;

2. Drawworks, rotary: 0.65.

D. The cable need only be sized for a maximum ambient temperature of 45 C in machinery spaces as determined by the U.S. Coast Guard, the American Bureau of Shipping and the Marine Transportation Committee of the Institute of Electrical and Electronic Engineers.

E. The cable shall meet the flame retardancy requirements of IEEE-383-1974 or IEEE-45-1977. Manufacturer shall supply to the owner of the vessel a certificate of compliance with this requirement.

F. The voltage rating of the cable shall be 1000 volts minimum.

G. For this specification, the cable insulation and jacket shall meet or exceed the requirements of the latest edition of one or more of the following standards as it applies to the construction of a single conductor power cable. Where the following standards do not specifically list AAR-sized cable, the insulation and jacket thickness shall conform to the next larger size cable listed.

1. Rubber-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-19-81);

2. Cross-linked Thermosetting Polyethylene-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-66-524);

3. Ethylene-Propylene Rubber-insulation Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-68-516);

4. Specification for Single Conductor Cleaning-stripping Ethylene-Propylene Rubber-insulated 0-600 Volt (see A and E of this interim guideline) Chlorosulfonated Polyethylene-jacketed Cable for Locomotive and Care Equipment (AAR Specification 591). NOTE: The insulation and jacket thickness of AAR 591 are suitable for 1000 volts based on comparison with ICEA S-68-516 for 0-2000 volt rating.

3.G.15 d. (cont'd) The manufacturer shall test, certify and label the cable with appropriate voltage ratings.

5. American Association of Railroads (AAR) Wiring and Cable Specifications S-501.

6. IEEE Recommended Practice for Electrical Installations on Switchboards (IEEE-45).

7. General Specifications for Cable and Cord Electrical for Shipboard Use (Military Specification MIL-C-915E).

8. Any UL-listed Marine Shipboard Cable

e. Motor Circuit Information.

Figure 1, reference 3.G.15.c

3-Phase, 208 VAC Motor Branch Circuit Quick-Reference Table for Single Banked Cables									
A	B	C	D	E	F	G	H	I	J
HP	FLA	Running Prot. 115% FLA.		Starter Size	Disconnect Size	Max. Prot. Device Full Volt Start			
		Adj.	Non-Adj.			Code C.B. 200%	B-E Fuse 250%	Code C.B. 250%	F-V Fuse 300%
.25	1.23	1.41	2	00	30	15	15	15	15
.33	1.48	1.7	2	00	30	15	15	15	15
.5	2.0	2.3	3	00	30	15	15	15	15
.75	2.8	3.22	4	00	30	15	15	15	15
1	3.6	4.14	4	00	30	15	15	15	15
1.5	5.7	6.56	8	00	30	15	15	15	20
2	7.8	8.97	10	0	30	20	20	20	25
3	10	11.5	12	0	30	20	30	30	30
5	17	19.6	20	1	60	35	40	50	60
7.5	24	27.6	30	1	60/100	50	50	70	80
10	31	35.7	40	2	100	70	70	90	100
15	46	52.9	60	3	100/200	100	100	125	150
20	59	67.9	70	3	200	125	125	150	200
25	75	86.3	100	3	200/400	175	175	200	250
30	88	101	110	3	200/400	200	200	125	300
40	114	131	150	4	400	250	250	300	350
50	143	164	200	4	400/600	300	300	400	450
60	170	196	225	5	400/600	350	350	500	500
75	212	243	250	5	600	500	500	600	-
100	273	314	350	5	600	600	600	-	-
125	343	394	450	6	-	-	-	-	-
150	396	455	500	6	-	-	-	-	-
200	528	607	800	6	-	-	-	-	-

Figure 1, reference 3.G.15.c (cont'd)

3-Phase, 208 VAC Motor Branch Circuit Quick-Reference Table for Single Banked Cables (cont'd)						
	K	L	M	N	O	P
HP	125%	Three Conductor Branch Cable				
		AWG (IEEE 45, 50 C)			TSGA - ( )	
		T	E, X	AVS	40 C	50 C
.25	1.54	14	14	14	4	4
.33	1.85	14	14	14	4	4
.5	2.51	14	14	14	4	4
.75	3.5	14	14	14	4	4
1	4.5	14	14	14	4	4
1.5	7.13	14	14	14	4	4
2	9.75	14	14	14	4	4
3	12.5	14	14	14	4	4
5	21.3	12	14	14	9	9
7.5	30.0	10	10	12	9	9
10	38.8	7	8	10	9	14
15	57.5	5	6	7	23	23
20	73.8	3	4	5	30	30
25	93.8	1	2	3	40	50
30	110.0	1/0	1	2	50	60
40	142.5	3/0	2/0	1/0	75	100
50	178.8	4/0	3/0	2/0	125	125
60	212.5	300	250	4/0	150	150
75	265.0	400	350	250	200	250
100	341.3	600	500	400	300	400
125	428.8	-	-	-	400	-
150	495.0	-	-	-	-	-
200	660.0	-	-	-	-	-

Figure 2, reference 3.G.15.c

3-Phase, 460 VAC Motor Branch Circuit Quick-Reference Table for Single Banked Cables									
A	B	C	D	E	F	G	H	I	J
HP	FLA	Running Prot. 115% FLA.		Starter Size	Disconnect Size	Max. Prot. Device Full Volt Start			
		Adj.	Non-Adj.			Code C.B. 200%	B-E Fuse 250%	Code C.B. 250%	F-V Fuse 300%
.5	1	1.15	2	00	30	15	15	15	15
.75	1.4	1.61	2	00	30	15	15	15	15
1	1.8	2.07	3	00	30	15	15	15	15
1.5	2.6	2.99	3	00	30	15	15	15	15
2	3.4	3.91	4	00	30	15	15	15	15
3	4.8	5.52	6	0	30	15	15	15	15
5	7.6	8.74	10	0	30	20	20	20	25
7.5	11	12.65	15	1	30/60	25	30	30	35
10	14	16.1	20	1	30/60	30	35	35	45
15	21	24.15	25	2	60/100	45	60	60	70
20	27	31.05	35	2	60/100	60	70	70	90
25	34	39.1	40	2	100/200	70	90	90	110
30	40	46	50	3	100/200	90	100	100	125
40	52	59	60	3	200	125	150	150	175
50	65	74.75	80	3	200	150	175	175	200
60	77	88.55	90	4	200/400	175	200	200	250
75	96	110.4	125	4	400	200	250	250	300
100	124	142.6	150	4	400	250	350	3350	400
125	156	179.4	200	5	400/600	350	400	400	500
150	180	207	225	5	600	400	450	450	600
200	240	276	300	5	600	500	600	600	-

Figure 2, reference 3.G.15.c (cont'd)

3-Phase, 460 VAC Motor Branch Circuit Quick-Reference Table for Single Banked Cables (cont'd)						
	K	L	M	N	O	P
HP	125%	Three Conductor Branch Cable				
		AWG (IEEE 45, 50 C)			TSGA - ( )	
		T	E, X	AVS	40 C	50 C
.5	1.25	14	14	14	4	4
.75	1.75	14	14	14	4	4
1	2.25	14	14	14	4	4
1.5	3.25	14	14	14	4	4
2	4.25	14	14	14	4	4
3	6	14	14	14	4	4
5	9.5	14	14	14	4	4
7.5	13.75	14	14	14	4	4
10	17.5	14	14	14	4	9
15	26.25	10	10	12	9	9
20	33.75	8	10	10	9	9
25	42.5	7	8	8	14	14
30	50	6	7	7	14	23
40	65	4	5	6	23	23
50	81.25	2	3	4	30	40
60	96.25	1	2	3	40	50
75	120	2/0	1/0	1	60	75
100	155	3/0	2/0	1/0	100	100
125	195	250	4/0	3/0	125	150
150	225	300	250	4/0	150	200
200	300	500	400	300	250	300

(1) <u>Examples of AC Motor Circuits</u>. Examples of 3-Phase AC Motor Circuits (reference 3.G.15.e). Use Quick-Reference Columns, Figure 1 above:

(a) Example No. 1. Single motor, 25 horsepower, 460V, code letter J, full voltage start, non-adjustable overloads, branch circuit breaker, Type T, IEEE 45 Cable, in 50 C ambient temperature space.
From Quick-Reference Columns, Figure 1:

D - Standard overload size nearest 115 percent full load; current is 40 amperes.

E - Starter size is 2.

F - If a disconnect is used near the motor, a 100 ampere size is sufficient, provided it is not fused above 100 amperes (if fusible). If part of a combination starter, the complete unit must be rated to handle the 25-horsepower motor.

I - The maximum standard size for the branch circuit protective device is a 90 ampere breaker.

3.G.15.e(1) (a) (cont'd) L - The cable used to power the motor must be rated for at least 42.5 amperes. For Type T cable in a 50 C ambient location Type T-7 is required

(b) Example No. 2. A 460 volt Motor Control Center (MCC) supplying one 30 HP, one 15 HP, and two 5 HP motors in 50 C ambient space. One 5 HP motor is a steering system pump. All are full-voltage starting; the 30 HP motor starter has protection with circuit breakers. Navy-type cable TSGA is used. First get data for each load; assume code letters F-V.

Quick-Reference Columns, Figure 2:							
Col. A	Col. B	Col. C	Col. E	Col. F	Col. I	Col. K	Col. P
HP	Full Load Amps	Adj. Over Load Size	Starter Size	Std. Disc. Size, If Used	Max. Branch Circ. Bkr (250%)	125% F.L.A.	50 C TSGA -()
30	40	46	3	100	100	50	23
15	21	24.2	2	60	60	26.3	9
5	7.6	8.7	0	30	N/A	9.5	4

Subchapter J does not address motor control centers directly; one must refer to NEC 430-24 and 430-62(a). Per 430-24, bus or cable in MCC must be sized for 125 percent of the largest plus 100 percent of the remaining motor full load currents, 50+21+7.6+7.6 = 86.2 amperes. If the MCC has spare sections, allowance shall be made for future growth. Breaker protecting entire MCC must not be larger than the largest rating or setting of the branch-circuit short-circuit and ground fault protection (based on Table 430-152) for any motor in the group, or 100+ 21+ 7.6+7.6 = 136.2 amperes.

A 125 amp circuit breaker would be adequate.

The 5 HP steering pump motor should be protected with a circuit breaker having adjustable, instantaneous (magnetic) type tripping only. This breaker must be set to open the motor circuit at 175 to 200 % of the locked rotor current. As will be shown, this setting should be 79 to 90 amperes.

(2) Tables.

NEMA AC General purpose, Class A Full Voltage Controllers, Single-Speed Squirrel Cage Motors.					
3-Phase Non-Jogging Duty					
Size	Continuous Duty Amps	200 VAC	Horsepower 230 VAC	460 VAC	Limit Amps
00	9	1.5	1.5	2	11
0	18	3	3	5	21
1	27	7.5	7.5	10	32
2	45	10	15	25	52
3	90	25	30	50	104
4	135	40	50	100	156
5	270	75	100	200	311
6	540	150	200	400	621
7	810		300	600	932

3.G.15.e(2) (cont'd)

3-Phase Jogging Duty					
Size	Continuous Duty Amps	200 VAC	Horsepower 230 VAC	460 VAC	Limit Amps
0	18	1.5	1.5	2	21
1	27	3	3	5	32
2	45	7.5	10	15	52
3	90	15	20	30	104
4	135	25	30	60	156
5	270	60	75	150	311
6	540	125	150	300	621

Note: From NEMA ICS 2-321 B

Motor Conversion Formulas.			
TO FIND	DC	AC – Single Phase	AC 3 Phase
AMPS when HP is known	$\frac{HP \times 746}{Volts \times Eff}$	$\frac{HP \times 746}{Volts \times Eff \times PF}$	$\frac{HP \times 746}{Volts \times 1.73 \times Eff \times PF}$
AMPS when KW is known	$\frac{KW \times 1000}{Volts}$	$\frac{KW \times 1000}{Volts \times PF}$	$\frac{KW \times 1000}{Volts \times 1.73 \times PF}$
AMPS when KVA is known		$\frac{KVA \times 1000}{Volts}$	$\frac{KVA \times 1000}{Volts \times 1.73}$
Kilowatts KW	$\frac{AMPS \times Volts}{1000}$	$\frac{AMPS \times Volts \times PF}{1000}$	$\frac{AMPS \times Volts \times 1.73 \times PF}{1000}$
KVA		AMPS x Volts	AMPS x Volts x 1.73
Power Factor PF		$\frac{KW}{KVA}$	$\frac{KW}{KVA}$
HP Output	$\frac{AMPS \times Volts \times Eff}{746}$	$\frac{AMPS \times Volts \times Eff \times PF}{746}$	$\frac{AMPS \times Volts \times 1.73 \times Eff \times PF}{746}$

Notes: (1) Power Factor and Efficiency should be expressed in decimals.

(2) If Power Factor is not given, assume 0.8.

(3) If Efficiency is not given, assume 0.8.

Single Phase Motor: Approximate Full Load Current.			
HP	115V	HP	115V
.33	7.2	2	24.0
.5	9.8	3	34.0
.75	13.8	5	56.0
1.0	16.0	7.5	80.0
1.5	20.0	10	100.0

Notes: (1) Values are for motors of normal speed and torque.

(2) For additional values, see NEC Table 430-148.

(3) For other KW ratings, voltages, and power factors:

$$AMPS = \frac{KW \times 1000}{1.732 \times Volts \times PF}$$

3.G.15.e(2) (cont'd)

Motor Locked Rotor Current.												
Max.	115VAC 1 Phase			208VAC 3 Phase			230VAC 3 Phase			460VAC 3 Phase		
HP	100%	175%	200%	100%	175%	200%	100%	175%	200%	100%	175%	200%
2	144	252	288	43	75	86	39	68	78	20	35	40
3	204	357	408	59	103	118	54	95	108	27	47	54
5	336	588	672	99	173	198	90	158	180	45	79	90
7.5	480	840	960	145	254	290	132	231	264	66	116	132
10	600	1050	1200	178	312	356	162	284	324	84	147	168
15				264	462	528	240	420	480	120	210	240
20				343	599	686	312	546	624	156	273	312
25				422	739	844	384	672	768	192	336	384
30				515	901	1030	468	819	936	234	410	468
40				686	1201	1372	624	1092	1248	312	546	624
50				825	1444	1650	750	1313	1500	378	662	756
75				1221	2137	2442	110	1943	2220	558	977	1116
100				1624	2874	3248	1476	2583	2952	738	1292	1476

Notes: (1) These values are to be used only if motor code letter is not provided.

(2) Values above calculated from NEC Tables 430-150, 430-151.

(3) If motor nameplate code letter is provided, the following applies

(a) See NEC Table 430-7(b) for code letter KVA/HP; and

(b) Locked rotor current, IL:

3-phase motors $IL = \dfrac{HP \times (KVA/HP) \times 1000}{1.73 \times Volts}$

$= \dfrac{577 \times HP \times (KVA/HP)}{Volts}$

1-phase motors $IL = \dfrac{HP \times (KVA/HP) \times 1000}{Volts}$